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APPLICATION FOR LETTERS PATENT
OF THE UNITED STATES

NAME OF INVENTORS: SYLVAN NADEAU
45-1000 Southdale Road East
London, Ontario, Canada N6E 1V1

TITLE OF INVENTION: DOUBLE STAGE ENGINE COOLING MODULE SUSPENSION

TO WHOM IT MAY CONCERN, THE FOLLOWING IS
A SPECIFICATION OF THE AFORESAID INVENTION

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DOUBLE STAGE ENGINE COOLING MODULE SUSPENSION

[0001] FIELD OF THE INVENTION

[0002] The invention generally relates to the reduction of electric motor structure-borne noise in engine cooling applications and, more particularly, to an effective means of isolating the motor's vibration from the rest of the vehicle to reduce in-vehicle structure-borne noise.

[0003] BACKGROUND OF THE INVENTION

[0004] In typical engine cooling modules, a DC electric motor is employed to drive a fan. The magnets of the electric motor are subjected to many fluctuating forces. These fluctuating forces generate vibration in the motor housing that can be transmitted to other components and thus, generate noise. Electric motor structure-borne noise is an important contributor to in-vehicle noise, vibration and sound quality in various conditions such as during wind-down or when a pulse-width modulation is used for motor speed control.

[0005] Accordingly, there is a need to provide decoupling structure to reduce the motor structure-borne noise in engine cooling applications.

[0006] SUMMARY OF THE INVENTION

[0007] An object of the invention is to fulfill the need referred to above. In accordance with the principles of the present invention, this objective is achieved by providing an engine cooling assembly including an electric motor, a fan driven by the electric motor, and a shroud at least partially surrounding the fan. First, resilient decoupling structure mounts the motor to the shroud in a manner to isolate vibration between the motor and the shroud. Second, flexible decoupling structure is associated

with the shroud and is constructed and arranged to mount the shroud to the shroud mounting structure in a manner to isolate vibration between the shroud and the shroud mounting structure, when the shroud is coupled to the shroud mounting structure.

[0008] In accordance with another aspect of the invention, a method of mounting an electric motor to a shroud and mounting the shroud to a shroud mounting structure includes, providing first, resilient decoupling structure mounting the motor to the shroud in a manner to isolate vibration between the motor and the shroud. Second, flexible decoupling structure mounts the shroud to the shroud mounting structure in a manner to isolate vibration between the shroud and the shroud mounting structure.

[0009] Other objects, features and characteristics of the present invention, as well as the methods of operation and the functions of the related elements of the structure, the combination of parts and economics of manufacture will become more apparent upon consideration of the following detailed description and appended claims with reference to the accompanying drawings, all of which form a part of this specification.

[0010] BRIEF DESCRIPTION OF THE DRAWINGS

[0011] The invention will be better understood from the following detailed description of the preferred embodiments thereof, taken in conjunction with the accompanying drawings, wherein like reference numerals refer to like parts, in which:

[0012] FIG. 1 is front view of an engine cooling assembly having first decoupling structure mounting a motor to a shroud and second

decoupling structure mounting the shroud to a shroud mounting structure, in accordance with the invention.

[0013] FIG. 2 is a cross-sectional view of first decoupling structure taken along the line 2-2 in FIG. 1.

[0014] FIG. 3 is a cross-sectional view of second decoupling structure taken along the line 3-3 in FIG. 1.

[0015] FIG. 4 is a graph of sound pressure level during wind-down comparing the prior art with the structure of the invention.

[0016] DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

[0017] With reference to FIG. 1, an engine cooling assembly is shown, generally indicated at 10, in accordance with the principles of the present invention. The assembly 10 includes an electric motor 12 that drives a fan 14. A shroud 16 at least partially surrounds the fan in the conventional manner. In the illustrated embodiment, the shroud 16 includes support structure 18 to which the motor 12 is mounted. First, resilient decoupling structure 20 mounts the motor 12 to shroud 16 in a manner to isolate vibration between the motor 12 and the shroud 16. In the illustrated embodiment, the decoupling structure 20 includes a plurality of mounts having at least a portion disposed between the motor 12 and the support structure 18 of the shroud 16. The mounts can be made of an elastomer such as rubber, can be springs or other flexible material to provide a resilient decoupling between the motor 12 and the shroud 16.

[0018] As shown in FIG. 2, a preferred embodiment of the first decoupling structure 20 includes a generally cylindrical rubber grommet 21 which receives a portion of an end cap 25 of the motor 12. A portion 23 of the

grommet 21 is disposed between the end cap 25 and the support structure 18 of the shroud 16. A fastener 27 passes through a sleeve 29 disposed through the end cap 25 and grommet 21. The fastener 27 is threaded into the support structure 18 to secure the grommet 21 to the support structure 18.

[0019] Second, flexible decoupling structure 22 is provided on the shroud 16 and is constructed and arranged to mount the shroud 16 to the shroud mounting structure 24 in a manner to isolate vibration between the shroud 16 and the shroud mounting structure 24, when the shroud is coupled to the shroud mounting structure 24. As shown in FIG. 1, the shroud mounting structure 24 is a frame disposed behind the shroud 16 and fixed within an engine compartment. The shroud mounting structure 24 can be a radiator, a condenser or other under-hood component. In the illustrated embodiment, the second decoupling structure 22 includes a plurality of mounts in the form of grommets 21' having at least a portion provided between the shroud 16 and the shroud mounting structure 24. Thus, the second decoupling structure 22 is configured substantially identically as the first decoupling structure, but is larger than each first decoupling structure 20. As shown in FIG. 3, a portion of the shroud 16 is received by the grommet 21' and each grommet 21' is secured to the shroud support structure 24 via a fastener 27. A portion 23' of the grommet 21' is disposed between the shroud 16 and the shroud mounting structure 24.

[0020] As shown in FIG. 4, a 6 dB wind-down noise reduction is achieved with the decoupling structure of the invention as compared to a mount where decoupling was used between a frame and a shroud, but a rigid coupling was used between the motor and the shroud.

[0021] In designing engine cooling module suspensions, a goal is to create the lowest frequency suspension. However, the highest naturally

frequency of the suspension should be limited to $\sqrt{2}$ times the frequency of excitation of interest. Thus, the highest natural frequency in a suspension using the decoupling structure of the invention should preferably be not more than $\sqrt{2}$ times the frequency of excitation of interest.

[0022] Since there is no rigid connection between the motor 12 and the shroud 16 or between the shroud 16 and the shroud mounting structure 24, motor structure-borne noise in an engine cooling application is reduced.

[0023] The foregoing preferred embodiments have been shown and described for the purposes of illustrating the structural and functional principles of the present invention, as well as illustrating the methods of employing the preferred embodiments and are subject to change without departing from such principles. Therefore, this invention includes all modifications encompassed within the spirit of the following claims.